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Lawrence Livermore National Laboratory

Vanadium Dynamic Strength Measurements

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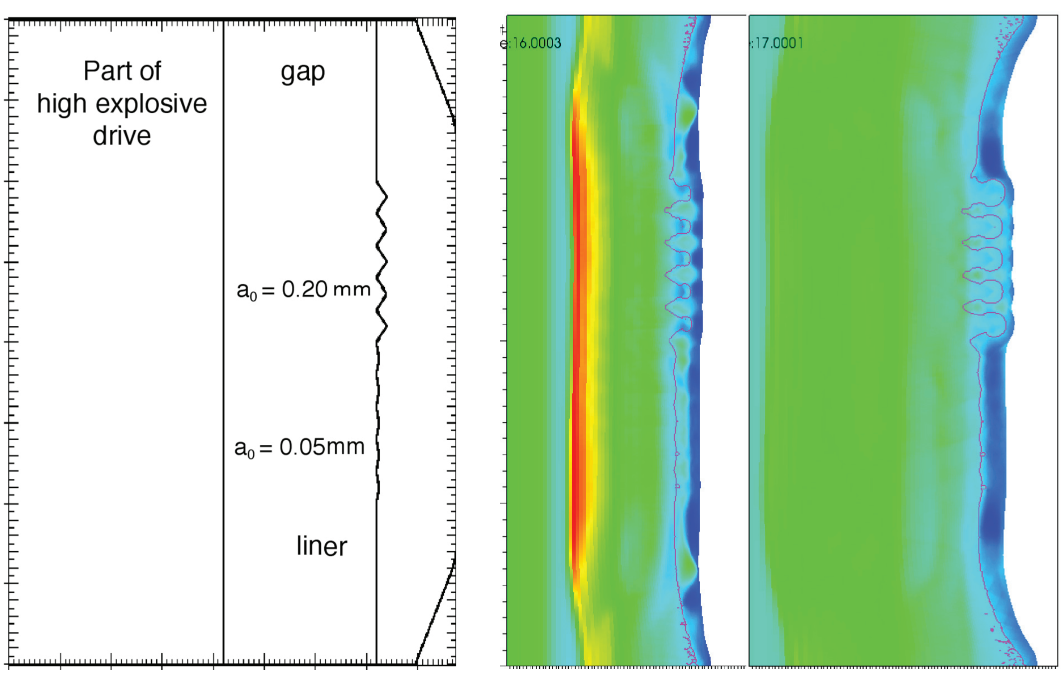
Project Description

The objective of this research is to investigate the dynamic strength properties of vanadium under dynamic loading conditions. The experiments will be performed by shock-free loading vanadium samples to peak pressures of 600 kbar and strain rates in the range of 10^5 to 10^6 s^{-1}. The loading conditions will be characterized by velocimetry (VISAR) measurements. Observation of the growth (or lack thereof) of Rayleigh–Taylor instabilities in vanadium samples that are quasi-isentropically loaded by a high explosive system designed by VNIIEF will be observed using flash x-ray radiography. The vanadium metal used will be provided by LLNL so that the initial microstructures can be matched to materials used in LLNL experiments conducted at higher strain rates and shorter durations of peak pressures using laser-driven loading. These coupled experiments will allow systematic changes to be mapped out over an unprecedented range of conditions.

In the experimental design component, the drive conditions will be characterized using VISAR velocimetry measurements. A rippled perturbation will be machined on the vanadium surface and shown to be measured to ±10 microns. Numerical simulations of the proposed design will be performed as a means of validation. Ten experiments will be performed using two different grain sizes of vanadium (five shots per grain size), peak pressure to 600 kbar, and strain rates in the range 10^5 –10^6 s^{-1}. Each vanadium target will contain two zones of perturbations with different amplitudes. VNIIEF and LLNL will separately develop, validate, and update material strength models for vanadium.



Left: Initial configuration of a typical experiment, showing a schematic of the high explosive, gap, vanadium liner, and the machined perturbations with two different amplitudes.

Right: Simulated evolution of the Rayleigh–Taylor instability.

Technical Purpose and Benefits

Several dynamic strength models have been implemented in LLNL hydrocodes, including the Preston–Tonks–Wallace and Steinberg–Guinan models. The constitutive model parameters have been primarily set from Hopkinson-bar, Taylor impact, and shock-driven experiments. Traditional experimental techniques are not well suited to provide data at strain rates in the range 10^5–10^8 s^{-1}. The need for experiments to validate strength models, set parameters, and refine models at these conditions is imperative in order to provide the necessary confidence in our predictive capabilities. Previous VNIIEF experiments and LLNL laser experiments have indicated that the strength models inadequately represent the physical phenomena occurring under these conditions. The principal goal of these experiments is to address this uncertainty and to provide strength models that accurately represent the physics.

ВНИИ

VNIIEF

Collaboration between Lawrence Livermore National Laboratory (LLNL), Livermore, CA, USA, and the Russian Federal Nuclear Center - All Russian Research Institute of Experimental Physics (RFNC-VNIIEF), Sarov, Russia

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A Publication of the Office of Advanced Simulation & Computing, NNSA Defense Programs. SAND 2007-4400P
Issued by Sandia National Laboratories for NNSA's Office of Advanced Simulation & Computing, NA-114. Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.